that the invasion encroached from the north by means of connection with James Bay around the north of the Laurentian positive area.

The unique assemblage in the limited area in eastern Wisconsin can not be considered an indigenous fauna because of its close connection with that confined to the Hamilton (Skaneateles) of eastern New York. The specific distinction is rather to be explained on the basis of non-contemporaneity, since both faunas were derived from the same mother oceanic association. Absence of several types or the presence of new ones in either of the areas is incidental and due to the changing character of the associations in the permanent basins and the ecologically varying conditions in the two regions. Stratigraphic and faunal inferences necessitate an extremely late Erian time equivalency for the Milwaukee formation, and it is probable that all of the Devonian in the eastern part of Wisconsin is later in deposition than any portion of the typical Hamilton.

PALEONTOLOGY.—*The status of the classification of the trilobites.*[1] E. O. ULRICH, U. S. Geological Survey.

The classification of the trilobites in both modern and older textbooks suggests that they fall as readily into line as though made to order. The genera and families seem sharply defined, and the descriptions seldom indicate any doubt regarding the soundness of the arrangement. However, the critical student who seeks to prove the indicated relationships for himself soon notes discrepancies and incongruities that grow and multiply till his confidence is weakened and finally almost destroyed. Such at least has been my experience during the twenty years or so that I have devoted mainly to the study of one after another of the genera and families of trilobites. The results of these studies, usually at variance with the views of the authorities, are only now being completed to the point where I might consider myself warranted in publishing them. But they were extensively employed and have always been available as paleontological criteria in the stratigraphic investigations that primarily occasioned the study of the fossils.

Prevailing conceptions regarding the systematic relations of the Ordovician and older trilobites are too largely based on overworked theories, weakly grounded deductions, and pure assumptions employed indiscriminately as though they were established facts and immutable

[1] Received January 3, 1929. Published by permission of the Director of the U. S. Geological Survey.

laws. In other words, quoting from a recent reviewer,[2] "The determination of the significance of structural conditions is based less on what may be or has been observed than on biologic theories." Though fully convinced that most of our theories of evolution are essentially true and properly applicable in certain cases, it yet seems to me they have been so burdened by unreserved and too often quite unwarranted applications that the confidence really due them has been seriously impaired. No laws of evolution have yet been discovered which, in the present state of knowledge, may be applied without reservation and severe limitation. Usually the actual genetic relations of extinct organisms, on the one hand, and the general trend of their evolutional modification, on the other, are only very obscurely indicated in the tangled and interwoven skein of life-processes that nature has preserved in accessible fossiliferous rocks. And so the paleontologist must do his part in working out the by no means simple methods through which the present stages in the ever changing expression of life history were achieved.

A moment's thought suffices to convince the worker that the available fossil remains are but occasional small bits of ramifying threads whose distal ends can only rarely be ascertained and whose proximal ends or roots are most difficult to recognize in the maze of heredity. Characters that are generally developed in the early stages of a particular line and subsequently lost, may be temporarily revived and without apparent warning in almost any of its later stages or off-shoots. In other cases the general trend of the evolution of certain parts is suddenly reversed. Such apparent anomalies not only result in mistaken conclusions regarding the age of the fossils, but they also inject unwelcome doubt as to the verity of previously fixed conceptions which seemed to work satisfactorily enough so long as the field of work was limited and disturbing factors were few enough to be neglected. Fossils were loosely identified, and the idea of local variations of species covered a multitude of stratigraphic sins. Now, however, since other ideas have crept into stratigraphy and our field of investigations has been extended to Paleozoic basins wholly unknown or barely touched before, the disturbing factors have become so numerous that they can no longer be ignored.

One of the striking collateral results of this expansion is the fact that more new things are in hand and awaiting publication than at any

[2] Rudolf Richter. Reviews in Neues Jahrb. Min. Geol. Pal., Jahrg. 1922, Bd. 2, Heft 3, 1923.

preceding time since we began to study fossils. But it should not be supposed that all or even most of these additions come from the recently discovered basins. On the contrary, by far the greater number have resulted from the more intensive and more securely founded restudy of fossil faunas and old collections that had been reported on long ago. As the sequence and field relations of geological formations became better understood, and the fact of frequent and varying oscillation of continental seas was established, the need of more intensive study of their fossil contents and the closer discrimination of species and varieties that would or might be of exact value in recognizing and correlating the particular stratigraphic horizons in which they occur became correspondingly pressing. The biological by-product of these more detailed studies is a steadily accumulating mass of data that bears directly on evolution in general and the genetic relations of fossil species and genera in particular. All of the various theories of evolution that still have adherents among zoölogists can find support in this mass of evidence. A master mind is needed to weave the scattered threads into a comprehensive scheme of organic evolution.

However, when it comes to the genetic relations of fossil species and genera the problems can be successfully attacked only by the specialists in stratigraphic paleontology. They have the required detailed knowledge of the concerned organic remains, and they alone have the exceedingly important stratigraphic information that enables them to check their knowledge of the things themselves with the chronologic aspects of each case. The latter factors, particularly as they concern the stratigraphic and paleogeographic ranges of the several specific and generic types, I deem absolutely essential before final conclusions are warranted.

Four conditions are mainly responsible for the many present doubts regarding the genetic and systematic relations of trilobites and other fossil organisms; and all arise from ignorance of the facts in the several cases.

First, and this applies especially to the trilobites, we know too little of the complete animal and can not entirely overcome the resulting doubt as to the original association of the dismembered parts that we bring together in describing our species and genera. Such features as the number and character of the thoracic segements, the free cheeks, eyes, doublure, epistoma, hypostoma, legs and other features of the ventral side, all of which are important factors in our inquiry, often remain entirely unknown.

Second, the available links in the lines of descent usually are too far apart.

Third, we often forget entirely or at least do not give adequate consideration to the fact that the geological record is far from complete, and thus we fail to appreciate the greatness of the break between certain systems. The effect of this lack of appreciation is particularly great in estimating the probable and possible changes that occurred during the exceedingly long time that separates the close of the Upper Cambrian and the beginning of the Ordovician, as these periods are now restricted and defined. An idea of its length is gained when we consider that two great systems of deposits, each fully equal in duration and possibly organic modification to either the Silurian or the Devonian system, are being slowly worked out and faunally characterized. Only a few years ago we knew practically nothing of the intervening Ozarkian and Canadian periods. And even now we are only beginning to realize what and how much happened during their terms in the way of modifying—in almost haphazard fashion—the ever-changing stream of life.

Fourth, since it has been established that the fossil marine faunas of deposits in continental basins invaded the latter, when occasion offered, from one or another of the oceanic realms in which their respective and characteristically different biota lived and accomplished the specific and generic changes observed in comparing the fossil faunas now accessible, the need of determining the originating source of the fossil remains has become no less essential in systematic investigations than in the age correlation of the beds containing them. Obviously, these determinations involve exceedingly complicated problems whose solution requires abundant and good material and much time. Progress is slow and usually not fast enough to keep abreast of new acquisitions.

To these four deterring conditions I might add another. This is the difficulty of correcting previous faulty or definitely erroneous determinations and plausible suggestions that have now become ingrained in the fabric of our text-books and literature in general. Most of these erroneous conceptions are occasioned by the usually laudable but incautiously exercised desire of zoölogists to bring into orderly arrangement the chaotic mass of inadequately studied fragmentary material on which, if we are to make any progress at all, we are obliged to found our descriptions of species and genera. In fact, though referring especially to the trilobites, we know so little about the subject in

general and about the genetic relations of the generic groups in particular that all preceding and any present effort to classify them into families and groups of higher rank can be nothing better than a provisonal arrangement. The paramount need of the present is to work out the facts.

PALEONTOLOGY.—Trachelocrinus, *a new genus of Upper Cambrian crinoids.*[1] E. O. ULRICH, U. S. Geological Survey.

Cambrian crinoids at all well preserved are extremely rare and desirable. They are particularly needed in these days when prevailing classifications are in course of modification along lines in which the genesis of the animals is being given greater consideration than heretofore.

The specimen that is the subject of this communication was collected by Dr. C. E. Resser and Mr. Robert Bassler from the upper part of the Gallatin limestone just above Hayden Falls, Republic Creek, a mile south of Cooke City, Montana. The particular bed in which the specimen was found is correlated with the "crinoid zone" of the Franconia formation in the upper Mississippi Valley where it lies between the top of the Ironton sandstone member and, as in the Montana section of the Gallatin, just under the widely distributed *Eoorthis* zone.

Though an unquestionable crinoid, it is exceedingly difficult to find a satisfactory resting place for this unique Cambrian fossil in any of the several classifications now in common use. It can hardly be referred to the Eocrinoidea: the stem is too well developed and the arms have a type of branching or pinnulation and a plate-covered ambulacral furrow, neither of which conditions is known to occur in that subclass. This crinoid is definitely of a higher order. Probably Jaekel's subclass Cladocrinoidea includes its nearest relatives, and it may be viewed as an early stage in the evolution of those crinoids. But none of the numerous cladocrinoid genera and families adopted or instituted by Jaekel can justly include our new crinoid. It must stand for the present as the type of both a new genus and a new family which we may provisionally place in the Order Dicyclica. This opinion is expressed despite the fact that considerable resemblance, at least in general aspect and structure, is notable on comparison with a large but as yet unpublished group of cystids that we have found in the Chazyan rocks of east Tennessee.

[1] Received January 3, 1929. Published by permission of the Director of the U. S. Geological Survey.